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Willingness to pay for reducing the risk of premature mortality attributed to air pollution: a contingent valuation study for Greece

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ABSTRACT

Development of strategies to control urban air pollution is a complex and multi–disciplinary process. In most real life cases, relevant policy making is characterised by the lack of information related to the economic value of the health consequences attributed to air pollution. This information is important to possess reliable economic estimates for the benefit arising from the application of the proposed strategies. This paper presents a contingent valuation approach in order to elicit the willingness–to–pay (WTP) for reducing the risk of premature mortality attributed to air pollution based on an easy–to–comprehend questionnaire. The economic value of increasing life expectancy by saving one year of life loss through improving air quality is estimated for Thessaloniki, Greece, which is considered one of the most polluted –if not the most polluted– cities within Europe, especially with respect to airborne particles. A sample of approximately 800 residents was chosen and a face–to–face interview was conducted using a hypothetical open–ended question designed to elicit the respondents WTP. Change in life expectancy was well understood and the results showed that 78.2% of respondents were able to express their WTP. The mean WTP to save one Year of Life Loss (YOLL) is approximately 920 € per person per year, which corresponds to a Value of a Life Year (VOLY) that is approximately 41 000 €.

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1. Introduction

Most economic activities that involve the use and conversion of energy are accompanied by emissions of air pollutants, thereby degrading the environment. Air pollution cause damages and impose risks on human beings, materials and ecosystems (Vlachokostas et al., 2010). In respect to public health, a consensus has been emerging among public health experts that air pollution, even at current ambient levels, aggravates morbidity (especially respiratory and cardiovascular diseases) and leads to premature mortality (e.g.; Kunzli et al., 2000; Katsouyanni et al., 2001; Holland et al., 2005; Hurley et al., 2005; Mukhopadhyay and Forssell, 2005; Dockery and Pope, 2006; World Health Organisation, 2006). In this sense, the feasibility and success of a control strategy is most critical. However, in most real life cases, policy making is characterised by the lack of information related to the economic value of health consequences attributed to poor air quality and especially regarding the risk of premature mortality, which is the output of non–market valuation approaches. This information is critical to possess reliable estimates for the economic benefit arising from the application of the proposed strategies– internalisation of external costs– in order to put the problem on the basis of economic efficiency from a societal perspective (Vlachokostas et al., 2009).

There is a general agreement among economic analysts that the economic values of benefits and losses are correctly assessed by two different measures. The value of a gain is appropriately measured by the maximum sum that people are willing to pay for it (also widely referred as the WTP measure). The value of a loss is accurately measured by the minimum compensation people demand to accept it (the so–called willingness–to–accept, or widely referred as the WTA measure) (Knetsch, 2007). In this context, damages from air pollution can be measured by how much people are willing to pay to avoid them, or by the minimum compensation they demand to accept them. Decisions to control can be justified by the WTP to perform it or by the compensation necessary to forgo it. However, one of the most popular anomalies, at least among resource economists and behavioural psychologists, is the observed disparity between two familiar and supposedly equivalent measures of economic value WTP and WTA (Brown and Gregory, 1999).

This paper presents a contingent valuation approach in order to elicit the willingness–to–pay for reducing the risk of premature mortality attributed to air pollution, based on an easy–to–comprehend questionnaire. Contingent Valuation (CV) is frequently used and is considered an appropriate method for evaluating the non–market value of goods such as health status and human life (e.g., John et al., 1992; Hanemann, 1994; Portney, 1994; Boardman et al., 1996; Wang and Mullahy, 2006; Alberini and Chiabai, 2007; Wang and Zhang, 2009). CV has been in use as a means of valuating a wide range of environmental goods and services for over 35 years, with over 2 000 papers and studies using this method, with the majority to originate from developed countries (Whittington, 1998; Carson, 2000). A thorough review can be found in the work of Venkatachalam (2004). In contrary to numerous studies on Value of Statistical Life, the CV of Year of Life Lost (YOLL) attributed to air pollution has received very little attention until recently (e.g., Johannesson and Johansson, 1997;

Soguel and van Griethuysen, 2000; Morris and Hammitt, 2001; Krupnick et al., 2002; NewExt, 2003; Chilton et al., 2004). According to the author's knowledge, the risk of any health impact attributed to air pollution has never been evaluated for the Greek population. This paper presents an attempt to fill this gap, given the seriousness of air pollution in Greece, especially in urban areas, where air pollution is one of the most pressing environmental problems, especially regarding the pollutants like particulate matter (PM) and ozone (O_3) (Moussiopoulos et al., 2009; Moussiopoulos et al., 2010).

Scientific literature depicts clearly the fact that WTA CV questions do not present reliable valuation and results (e.g., Arrow et al., 1993). In this light, the immediate objective of this study is to estimate the WTP measure for the risk of premature mortality due to air pollution and consequently the Value of a Life Year (VOLY). A sample of approximately 800 residents was chosen based on stratified probability sampling. A face–to–face interview was conducted using the open–ended format and specifying a realistic payment vehicle, designed to elicit the respondents WTP for air pollution control in the city of Thessaloniki, Greece. The area is selected on the grounds that Thessaloniki is considered one of the most polluted –if not the most polluted– cities within Europe, especially with respect to airborne particles (Organisation for the Master Plan and Environmental Protection of Thessaloniki, ORTh, 2008; Official Airbase web site, 2010). The present study also examines the associations between WTP and its determinants, and explores the feasibility of the application of CV methods in Greece. In a second level, the work aims to support environmental managers and public authorities' planning schemes in order to analyse relevant costs and benefits of policy interventions by avoiding the uncertainties of benefit transfer methods (Navrud, 2004; EC, 2005), which represent the only alternative to fill in gaps in the availability of information on the preferences of individuals in a country or a region.

2. Methodology

2.1. Study area

The city of Thessaloniki is situated in the northern part of Greece. With more than one million inhabitants (approximately 10% of the Greek population) and approximately 20% of the country's industrial activity, it is one of the largest urban agglomerations in the Balkans. Vehicle and industrial emissions are the two main sources of air pollutants in the Greater Thessaloniki Area (GTA). With the vehicle fleet growing at an annual rate of 5–7% (Official General Secretariat of National Statistical Service of Greece web site, 2010), radical improvements are not expected in the coming years. Interannual trend of monitored pollutants is presented analytically in Moussiopoulos et al. (2009). Particulate air pollution, which is a combination of smog, industrial dust and natural dust, constitutes one of the most pressing environmental problems in the GTA especially in the urban core, where human exposure to increased PM concentrations in the densely populated urban city centre is high and far from meeting the EU legislation (Moussiopoulos et al., 2009) and/or World Health Organisation's air quality guidelines.

A criticism for the CV method lies in the fact that respondents may not be familiar with the scenarios described in CV questions. Thus, respondents' preferences are not well–defined with respect to the issues described (e.g., Diamond and Hausman, 1994; Wang and Mullahy, 2006). However, this is not the case for the city of Thessaloniki which –as already discussed– is selected as a case area on the grounds that it is considered one of the most polluted cities within Europe and the most polluted city in Greece. The accumulation of exceedance days for more than half of the year within the limits of the metropolitan centre of Thessaloniki is well communicated by all media to the public, and thus respondents are familiar with poor air quality issues. Our study indicates that more than 74% of respondents were (quite and very) concerned about urban air pollution. This fact laid the foundation for our investigation into the citizen's WTP for air quality improvement in the area.

2.2. Study design, questionnaire and sampling

In order to obtain meaningful results, the change of utility that occurs due to the impact to be assessed has to be understood. This implies that it is important to value damage, not a pressure or effect. For instance, it is not so useful to ask for the willingness–to–pay to avoid an amount of emissions, say tonnes of PM_{10}, as no one –at least without further information or knowledge– can judge the severity of this or the damage or loss of utility caused by this. On the other hand, if the respondent is asked for an assessment of a concrete health risk, especially as important as the risk of life loss due to air pollution, a comparison of this impact with other impacts and changes of utility that the respondent experiences is available. To get useful results, impacts are described and explained as clearly as possible before measuring preferences. Thus, in the material to follow the assessment is based on the (measured) stated preferences of the affected, well–informed, population. The study focuses on gains in life expectancy in normal health, attributed to chronic exposure to air pollution.

A strategic decision regarding the study and questionnaire design is the selection between the open–ended WTP question format (OE) instead of the dichotomous–choice (DC) format. The comparative reliability of OE and DC CV is of practical importance to analysts who need to choose between the two techniques. In principal, the advantages of DC CV include the following; (i) fewer mental demands are placed on the respondent, resulting in lower item non response; (ii) there is a question format matching that of a market setting, in which the price is stated and the individual engages in "price–taking" behaviour of buying or not buying at that price; and (iii) the DC format is an incentive compatible device for respondents to reveal their true preferences about provision of the good. While DC CV has many significant advantages, these benefits are not without costs. One cost is that WTP must be inferred, and the resulting estimates may be sensitive to the assumptions made about the specific utility function (distribution of the error term, and associated functional form of the estimated logit equation). The advantage of OE CV is that WTP is directly elicited and inference is not required. However, from the respondent's viewpoint, stating a specific WTP amount is mentally a more difficult task, often resulting in item–non response or underestimates of WTP (Loomis, 1990). Based on the above rationale, the questionnaire design was initially planned to be disseminated in an OE format, since according to the author's belief, the main advantage of OE contingent valuation is that WTP is directly elicited and inference is not required.

As a first step, a pre–test procedure –pilot survey– was conducted in March 2009 in order to assess the comprehensibility of the designed questionnaire and the effectiveness of the survey to follow. Simplicity and comprehensibility of the questionnaire were considered top priorities of the approach adopted in the framework of this analysis, since an easy–to–comprehend and disseminate questionnaire would significantly increase the potential number of respondents. The pilot survey considered both OE and DC formats. It should be emphasised that most of the respondents who participated in the pre–test procedure, considered the OE format as more appropriate than a DC scheme in the WTP questions. Respondents clearly stated that an open–ended question created a spontaneous and less "guided" approach. Additionally, most of the respondents stated that they did not want to respond in a predefined way and that DC format gave them the limited opportunity to answer in a way which may not match their actual opinion. Although it is considered as a more difficult task, WTP non–response behaviour was not occurred since the interviews were conducted on a face–to–face basis by trained

interviewers. On this basis, the final questionnaire included the OE WTP questions. However, DC should be also considered (Arrow et al., 1993). In this sense variation in the kinds of questions, such as using DC for some respondents and OE for others, so as to allow for comparison of whether the responses depend on the way the valuation question is framed, is considered a future challenge for the authors.

The pilot–study procedure ascertained that all 40 participating respondents understood the questions, with focus on the content of the WTP questions. After making the appropriate modifications and improvements, mainly increasing comprehensibility of the composed questionnaire to the respondents where problems were encountered, the final questionnaire consisted of three discrete, but interrelated parts. The first section contained socio–economic questions, including those relating to full name, gender, age, education, region of residence, and average monthly income (background questions). It should be noted that 5% of the respondents were reluctant to state their economic status.

The second part included questions which referred to the respondents' opinion on their level of information regarding air pollution involved air quality status in Thessaloniki, legislative issues, snapshots of both "deteriorated" and "improved" urban air in the city, in order to advance understanding of current air pollution levels. Additionally, taking also into account the fact that the aim was to describe the scenario as clearly as possible in order to avoid possible errors and biases for the CV results derived, the interviewers explained in detail air quality improvement programmes (e.g., types of programmes, relevant costs, implementation and applicability issues), nature of the payment vehicle (introduction of a green tax) and other institutional arrangements for sustaining these programmes. Finally, they were asked for other probable misunderstandings regarding the questionnaire at hand. The second part, which can be characterised as preparatory for the questionnaire's third section concluded in the significant results depicted in Figure 1. Figure 1 highlights the maturity of the selected population in regard to air pollution issues and their relation to loss of life expectancy and premature mortality.

More specifically, more than 70% of the respondents believe that they are "moderately to very well" informed on issues related to air pollution. Approximately 75% of the sample is "quite" to "very" concerned on the effects of air pollution on public health, with less than 7% not to be very concerned on the issue. More than 60% of the respondents believe that traffic is the main source of air pollution in Thessaloniki and approximately 30% consider that the main source is the industrial sector, a fact that it is more or less expected, since urban arteries seems saturated in morning and evening peak hours. The respondents' impression is very close to the truth as regards the current status for the metropolitan centre of Thessaloniki (Vlachokostas et al., 2009). Last but not least, it should be emphasised that more than 80% of the respondents believe that improving air quality would increase the population's life expectancy, enhancing the decision for conducting the present survey. On this basis, the second part of the questionnaire constitutes the background for the investigation concerning the citizen's WTP for air quality improvement in the area.

The last section consisted of the "core" questions regarding the CV survey. The introductory question to this section, which forms the interface with the previous part, is the one which investigates the belief of the respondents to the statement that air pollution control would increase significantly their average life expectancy. Considering the fact that some respondents may have taken it literally to mean that they will live to be e.g., 81 years of age instead of 82 and this lost year will happen a long time from now, a clarification was realised for the actual way that lifetimes are shortened by air pollution. It is clearly mentioned from the interviewers that this has to do with a change of the chance of dying each year, and consequently what is lost does not just happen at the end of life, but a lost expected year is partially the chance of dying this year and the next year, and so on. This is followed by two WTP questions, based on the specification of a realistic payment vehicle, i.e. increase in taxation with the introduction of a green tax. The first question seeks the probability of a positive WTP i.e., the respondents who reported a WTP value greater than zero were treated as positive WTP. In the case that the interviewee provided a positive answer, the question was followed by the open–ended valuation clause; "If YES and having in mind that the life expectancy for the city of Thessaloniki is 82 years for women and 77 years for men, what is the maximum sum of money that you are willing to pay (in present values) on a monthly tax for the rest of your life in order to increase your average life expectancy, a) for six months?.....; b) for one year?....., by improving air quality with a series of air pollution control measures". Those "unwilling to pay" were also asked a follow–up question to establish their reasons for rejection and who they believed should be responsible for covering the costs of air pollution control measures.

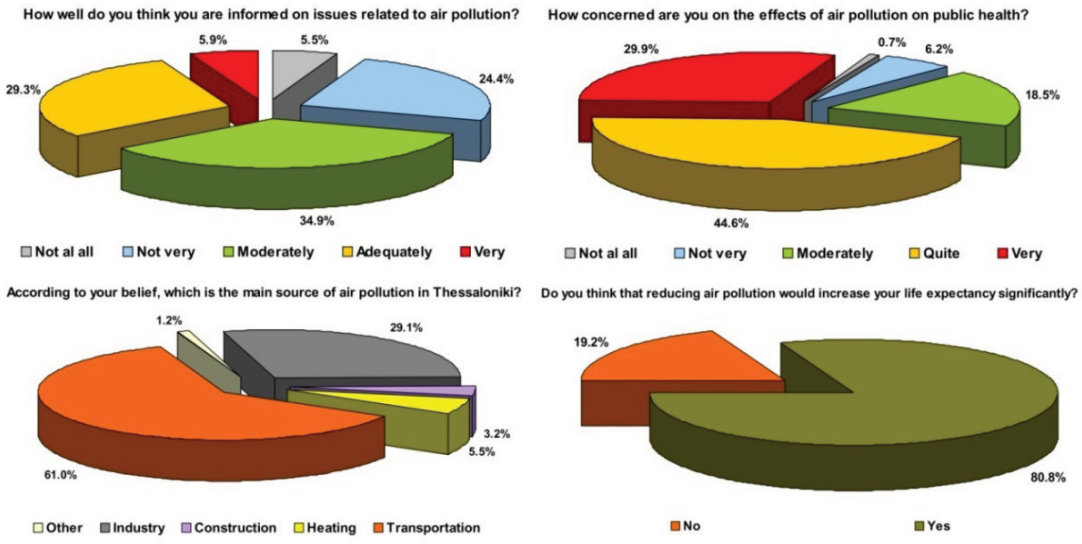

Figure 1. *Respondents level of familiarity with air pollution and public health issues, focusing on loss of life expectancy.*

The survey was conducted in the period between April and July 2009. Interviews were conducted on a face–to–face basis by trained interviewers. A random selection of more than 800 adults based on stratified probability sampling was realised. The respondents agreed to participate in the survey and were chosen from Metropolitan Centre of Thessaloniki, Eastern Thessaloniki, Western Thessaloniki and Suburban municipalities. The number of sampling units was determined according to the population in each district to ensure representativity. All the respondents were 18 years old or above and they were notified that they should consider the introduction of a green tax as a realistic payment vehicle in the survey under consideration.

Statistical package SPSS 17.0 was applied to calculate the relationship between WTP and influential factors. After initial statistical analysis (descriptive statistics, Pearson correlation and partial correlation coefficients), we used the Probit model to identify the variables that affect the respondents' final decision on WTP. Then, a stepwise linear regression model was performed to determine the factors affecting the amount of a positive WTP.

3. Results and Discussion

3.1. Sample characteristics and VOLY results

As already discussed, the aim of the study was to question a representative sample of the population in the area under consideration. The average age of the sample of respondents is 36, very close to the average population age, according to the National Statistical Service of Greece. The mean household income of respondents participating in the presented survey is approximately 2 260 € per month, compared to the average household income of 2 192 € as reported by NSSG for 2004. In that sense income level is also comparable. The percentage of respondents with tertiary education is 47.2%, while for city residents it is considerably smaller, not particularly problematic considering the nature of the presented study. As concerns the percentage of male respondents, those accounted for 47.8% of participants while the average ratio of males in the urban region was 48.3%. In this light, the gender balance between the sample and the area's population is nearly identical.

In the presented survey, the questionnaire adopted was well accepted by most of the respondents. Approximately 22% of the respondents were "unwilling to pay" in the WTP question. This is consistent with the typical number of non–responses in a CV study ranges from 20% to 30% (Wang and Zhang, 2009). WTP responses for the increase of life expectancy due to air quality improvement in Thessaloniki are presented in Table 1.

Table 1. *WTP responses for air quality improvement in Thessaloniki*

WTP (€/month)	To increase life expectancy by six months		To increase life expectancy by one year	
	Frequency	Percentage (%)	Frequency	Percentage (%)
0	131	20.9	88	14.1
<10	174	27.8	105	16.7
11-50	217	34.6	240	38.3
51-100	68	10.8	98	15.6
101-200	20	3.2	57	9.1
201-500	15	2.4	28	4.5
501-1000	2	0.3	10	1.6
>1000	0	0.0	1	0.1
Total Valid	627	100	627	100

From 627 valid (means omitting those unwilling to pay) responses, 88 interviewees (14%) that were hypothetically unwilling to pay for one YOLL gain were treated as "true WTP zeros", since they stated a zero price. This, in turn, means that the distribution of the WTP in the sample is skewed unevenly and that the median value is lower than the mean value. The respondents with positive WTP (WTP>0) were split into seven classes, according to the amount of money that they are willing to pay. Since there is a rather large share of zero responses and most respondents stated a rather low WTP, the mean WTP is very sensitive to any extreme responses. Table 1 shows that the respondents are more sensitive to one year gain in life expectancy, since the distribution is skewed to the right.

In order to calculate VOLY from the stated WTP we used the remaining life expectancy ΔLE_i calculated by means of the gender and age of each respondent *i*. More specifically, for $VOLY_{6,months}$, which is the VOLY based on the stated WTP to increase life expectancy by six months ($WTP_{6,i}$), the relevant formulation is expressed mathematically as:

$$VOLY_{6,months} = \frac{1}{N}\sum_{i=1}^{N}(WTP_{6,i}\ 12)\ 2\ \Delta LE_i \quad (1)$$

For the corresponding $VOLY_{12,months}$, which is based on the stated WTP to increase life expectancy by one year ($WTP1_{12,i}$) the relevant formulation is expressed similarly as:

$$VOLY_{12,months} = \frac{1}{N}\sum_{i=1}^{N}(WTP_{12,i}\ 12)\ \Delta LE_i \quad (2)$$

where *N* is the number of valid responses and ΔLE_i is the life expectancy calculated by means of the gender and age of each respondent *i*.

The relevant calculations based on the above rationale are presented in Table 2. It should be underlined that mean and median WTP values reported in Table 2, were estimated from a descriptive non–parametric analysis, excluding the protest responses. However, considering the fact that a considerable number of true zeros exists in the sample of responses, appropriate econometric analysis using the Censored Tobit model was also performed (Tobin, 1958). Censored Tobit analysis contributes to completeness of the approach and comparability issues. It should be noted that the econometric analysis of the dataset resulted to slightly decreased values regarding the mean WTP_6 (39 €/month compared to 40 €/month from non–parametric analysis presented in Table 2) and the mean WTP_{12} (76 €/month compared to 77 €/month from non–parametric analysis presented in Table 2). However, Censored Tobit analysis resulted to significant increased values regarding the median WTP_6 (34 €/month compared to 20 €/month from non–parametric analysis presented in Table 2) and the median WTP_{12} (70 €/month compared to 30 €/month from non–parametric analysis presented in Table 2).

WTP mean values are in proportion to the length of the life extension gained. That is to say that the 12 month/6 month ratio is 1.9, very close to 2. This means that the respondents were able to see the difference between the risk of increased life expectancy between 6 months and 1 year as a life extension. Moreover, as usual in CV surveys, the mean WTP is higher than the median. The median is preferred by part of the scientific community because it is less sensitive to high outliers that are not considered representative or realistic. Median is thought as a conservative, but robust and a more reliable estimate (EC, 2005). However, others argue that choosing the median is closer in spirit to typical yes/no choices in democratic elections. In order to determine a VOLY for environmental policy it seems more appropriate to take the strength of each response into account, and this is realised by using the mean value approach. More discussion on this can be

Table 2. *VOLY estimations based on WTP and WTA measures*

Variables	To increase life expectancy by six months		To increase life expectancy by one year	
	Mean	Median	Mean	Median
WTP per person (€/month)	40 (95%CI:34-47)	20	77 (95%CI:65-89)	30
VOLY(€)	41 211 (95%CI: 35 000 – 47 000)	13 920	40 621 (95%CI: 34 000 – 47 000)	13 680

found in Desaigues et al. (2007). In any case, both approaches, together with all non–parametric and parametric outputs, are presented for comparison reasons in the framework of this analysis.

On top of the above analysis, one issue should be raised at this point. Air quality is considered to be a pure public good which is non–competitive and free for all population. Therefore, it is generally more difficult to get people to pay for it. Even though people are familiar with air pollution, what they may not be very familiar with is paying for improved air quality. However in the case that a population is already familiar with paying for improved air quality, e.g., through "averting expenditure", then the open–ended WTP values could be compared with the averting expenditure incurred so that a "criterion validity" could be tested. Similarly, comparison of open–ended values and discrete choice values (if employed) would have been useful for testing the "convergent validity" of the results. This study consists a future challenge for the authors.

Respondents may conclude that they can enjoy the benefits of a group's success regardless of the extent of their own efforts, so why risk bearing the costs of what might turn out to be a failed investment of resources? People frequently calculate that there is little incentive to bear the costs of attempting to achieve better air quality (Wang and Zhang, 2009). In this light, WTP can be considered as a more economically rational measure than willingness–to–accept (WTA) in order to estimate VOLY. Moreover, the WTA measure, though relevant in the context of pollution damage, depends mainly on the underlying property rights. Since people do not have well–defined property rights over air quality, on what basis they are entitled for "compensation" is an important question. In any case, it is well known in the literature that WTA CV questions do not work (see Arrow et. al., 1993) and thus they are not included in the framework of the present analysis.

3.2. Unwillingness to pay and protest attitude

Open–ended survey questions can typically elicit a considerable number of protest responses, which is often seen as a pitfall of the open–ended question format (Brown et al., 1996; Carson, 2000). Respondents were not given a ready market price to choose, thus they had to provide a precise WTP amount themselves, which may result in their protested attitude. In essence, all respondents who state their unwillingness to pay have basically WTP=0. In the framework of this analysis, and regarding the WTP question concerning one YOLL, 263 respondents answered that they refused to pay for air quality improvement. All of them were asked a follow–up question to put forward their most important reason for their refusal to pay and who they believed should be responsible for covering the costs of air quality improvement. Of the 263 respondents, 175 refused to be a part of the WTP question and state a value, presented a negative attitude and are characterised as "protested votes". Their negative attitude was based on three main reasons: (i) "it is the government's responsibility", (ii) "polluter's should pay", (iii) "life is invaluable". It should be underlined that these are not considered for estimating the average WTP. Of the 263 respondents, 88 stated their unwillingness to pay with a zero price, but without protest to the WTP question. Their attitude was based on two main reasons: (i) "Income is too low to afford it" and (ii) "Increased life expectancy by 6 or 12 months is too short".

More specifically, regarding the sum of the 263 unwillingness to pay responses, 34.2% of those respondents had quite high expectations of the government, since they expressed that air pollution control is a governmental obligation (Table 3). On top of this, some respondents added that, since they pay taxes, the government should use part of this money for air pollution control and therefore they rejected the introduction of a new green tax. In contrast to their confidence in the government, 21.1% of respondents believed that polluters should pay for air quality improvement, e.g., through taxes to industries. Regarding the aforementioned third explanation for a "protested vote" that life is invaluable, 11.2% of the respondents were aligned with this specific attitude. Those think this approach as unethical. Some of the respondents stated all of the above reasons and they were asked to prioritise in order to be classified in Table 3. Additionally, 19.6% of the respondents had income which was too low to afford it, 10.4% believed that increase of life expectancy by 6 or 12 months is too short, thus insignificant for them to pay. 3.5% stated zero WTP for other reasons or they did not want to state their specific reason, but they did not raise any protest attitude. More discussion on the conceptual background regarding zero WTP value can be found in the work of Bateman et al. (2002).

3.3. A model for positive WTP

Probit Analysis is designed to model the probability π_i of response to a stimulus and is most appropriate in order to estimate the effects of one or more independent variables x_{ij} on a binomial dependent variable and establish a relationship between some certain population characteristics i.e., $\pi_i = c+(1-c)F(b_0+b_1x_{i1}+b_2x_{i2}+...+b_px_{ip})$. The probit analysis model can also be considered as a type of generalised linear model that extends the linear regression model by linking the range of real numbers to the 0–1 range, since the probability of an event must lie between 0 and 1.

Two probit models were estimated for describing WTP in relation with a set of social variables and air pollution awareness variables. Age, gender, education level and average monthly

Table 3. *Respondents' reasons for unwillingness to pay and protest attitude (N=263)*

Reasons for rejection	Characterisation	Percentage (%)
It is the government's responsibility	Protest votes	34.2
Polluters should pay	Protest votes	21.1
Income is too low to afford it	"True zeros"	19.6
Life is invaluable	Protest votes	11.2
Increase life expectancy by 6 or 12 months is too short	"True zeros"	10.4
Other reasons	"True zeros"	3.5

income were the regressors of the first model. Those parameters were chosen in the effort to come up with an easy–to–gather data model which produces a rough estimation of WTP influencing parameters for any area under consideration. In the second model, the respondents' level of air pollution awareness, their concern regarding air pollution and public health association and especially their belief considering the risk of premature mortality due to deteriorated air quality were further added to regressors. Model 2 presents better results as regards the parameters influencing WTP, however it requires more data which in many cases may be difficult to obtain. Results and parameters estimated are synoptically presented in Table 4. Model 1 revealed that income and age are key factors of the citizens' tendency to positive WTP, while in Model 2, higher concern about health problems and mortality attributed to air pollution have a strong positive impact on the probability of a positive WTP. For both models, the goodness of fit test expressed the validity of the model used.

Table 4. *Probit models for the probability of positive WTP*

	Model 1		Model 2	
	Coefficient	**Standard Error**	**Coefficient**	**Standard Error**
Age	0.078 [b]	0.041	0.059	0.037
Gender	0.042	0.024	0.032	0.028
Education	0.012	0.005	0.009	0.004
Income	0.184 [a]	0.066	0.088 [b]	0.058
AP awareness	-		0.072	0.048
AP, health and mortality			0.777 [a]	0.289

[a] and [b] indicate coefficients are significant at the 0.05 and 0.1 levels respectively.

As a next step, an effort to describe the amount of WTP by a set of dependent variables using a linear regression model was realised. Stepwise regression analysis was employed for this quantitative study and the results are presented in Table 5 (Model A). The regressors were chosen according to standard statistical procedures at the significance level of 0.05. Income and association between AP, health and mortality seem to be the only statistically significant regressors of Model A. Obviously, social–demographical factors were assessed as insignificant and were not included in the regression equation, meaning that they are high related with the citizens' willingness to pay, but not associated with the amount.

4. Conclusions

Assessment of the effects of air pollution on health is an area of the interface of science and policy where quantitative Health Impact Assessment/Cost Benefit Analysis methods are most strongly developed and used. Given the fact that air pollution control requires significant capital investments, health improvements, and mainly premature mortality issues attributed to air pollution, are usually considered as the major justification for such investments. Consequently, one problem with practical and ethical dimension that the decision maker/ environmental manager is facing is that of placing a value on the health impacts attributed to air pollution and especially of the loss of life expectancy. However, internalisation of externalities to assist policy and decision–making is a way to build the bridge towards sustainable development. Monetary valuation of health impacts attributable to air pollution is important to be included otherwise there is a deficient picture of the range of adverse effects attributable to air pollution and the benefits to health from reducing it. The economic valuation of health impacts from air pollution demonstrates the potential for using economic analysis of health outcomes to help identify priority environmental problems, and efficiently target investments in air pollution control.

However, in most real life cases, relevant policy making is characterised by the lack of information related to the economic value of the health consequences attributed to poor air quality and especially regarding the risk of premature mortality. This study is the first known CV study up to the authors' knowledge that relates to the issue of air pollution in Greece. The economic value of increasing life expectancy by saving one YOLL through improving air quality is estimated for Thessaloniki, Greece. The results show that nearly 80% of respondents were able to express their WTP. The mean WTP to save one YOLL is approximately 920 € per person per year, which corresponds to a VOLY that is approximately 41 000 €.

The basic lesson learned from the survey conducted and herein presented is the fact that people are most concerned about urban air pollution and how much this affects their health and everyday life. Moreover, since the survey was realised with face–to–face interviews, the interviewees had the chance to be provided with snapshots of "deteriorated" and "improved" urban air quality within the city, which helped a lot in their understanding of air pollution levels. Like all other methods, survey research has special strengths and limitations. Clarification and knowledge of these can provide the background for practitioners in similar future CV studies. In this direction, the relatively little cost that was required to collect a lot of scientific information on a number of variables from a large number of persons need to be outlined. Moreover, since the survey was combined with sampling, results can be generalised to large populations of people as the one of the GTA. On the other hand, surveys as the one herein presented also have a number of limitations. The most serious weakness concerns the validity and reliability of the responses obtained to questions. They only provide verbal descriptions how respondents about a specific, in most cases complicated, issue. What should be treated with scepticism is the fact that in many cases responses cannot be taken as accurate descriptions of what the respondents actually believe, especially when such beliefs come in contrast to a generally accepted norm of their society. Thus, interviewees might be unwilling to indicate that their behaviour is much differentiated from the one most accepted by their group. In that sense, researchers need to take into account this serious limitation as they interpret their results. Last but not least, a strategic decision regarding the study and questionnaire design lies in the selection between the open–ended question format, instead of the dichotomous–choice, an issue that has been thoroughly discussed in Section 2.2. However, despite the seriousness of the aforementioned limitations, surveys present a valuable tool for environmental managers worldwide and need to be treated as such.

Table 5. *Results of stepwise regression of WTP (Model A)*

Explanatory variable	**Regression Coefficients**		**T value**	**P value**	**95% CI**		**Co-linearity statistics**	
	B	**Std. Error**			**Lower Bound**	**Upper Bound**	**Tolerance**	**VIF**
(Constant)	-2.014	3.689	-1.262	0.030	-9.244	5.216		
Income	0.007	0.002	2.835	0.005	0.002	0.011	0.999	1.001
AQ and mortality	23.881	6.655	3.599	0.000	10.837	37.180	0.999	1.001

Clearly monetary valuation is an interdisciplinary undertaking linking natural science with social science, and as such a full range of perspectives on human behaviour is required including social psychology, political science, sociology and applied philosophy (Spash and Vatn, 2006). While more realistic valuations using more appropriate measures of gains and losses can be implemented on current evidence, further improvement in the guidance provided by cost–benefit and other such assessment studies would likely follow from better information, particularly in two areas. The first is the extent to which there are differences between WTP and WTA valuations of different kinds of environmental changes. The second is the extent to which people regard various types of changes as gains or as reductions of losses the conditions or causal factors that determine the reference state they use in judging their value. However, perhaps the most serious problem related to contingent valuation studies may be the fact that no real payment is undertaken, even though a realistic payment vehicle is described and introduced. This fact may induce the respondent to overlook his or her budget constraint, consequently overestimating his/her stated WTP.

Undoubtedly, the current state of knowledge has still gaps and uncertainties and thus the findings with respect to WTP presented herein should be interpreted with caution. More studies with alternative methods should be implemented in order to confirm the findings of this study for better economic valuation and, therefore, better environmental policy. Other stated preference methods e.g., discrete–choice CV methods (Bosch et al., 1998; Smith, 2000), would be alternative approaches to reduce the inherent bias in future studies. Different research methods may have been used across study–sites, including what question(s) was asked, how it was asked, what was affected by the management or policy action and how the environmental impacts were measured. The purpose of ongoing research is to reduce gaps and in addition to refine the methodology to reduce uncertainties. Clarity in defining monetary valuation issues is a prerequisite for proper interpretation of the results in the policy arena. Nevertheless, the results are often prone to misinterpretation, even when the assessment is carried out carefully, and its multiple uncertainties are carefully presented and explained to decision makers, the press, and the public (Krzyzanowski et al., 2002). Nevertheless the estimations presented in the framework of this analysis can be used to assist cost–benefit analysis, which can lead to the optimal level of air pollution that corresponds to the point where the net economic benefit from a societal perspective is maximised. In that way, the problem is shifted to a social prosperous basis.

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